

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:)
TAKEHIKO NAKAI)
Appln. No.: NYA)
Filed: Herewith)
For: DIFFRACTIVE OPTICAL)
ELEMENT AND OPTICAL)
SYSTEM HAVING THE SAME) September 21, 2001

The Commissioner for Patents
Washington, D.C. 20231

PRELIMINARY AMENDMENT

Sir:

Preliminary to examination, please amend the above-identified application, filed herewith, as follows:

IN THE SPECIFICATION

Please amend the paragraph at page 10, lines 4-6, to read as follows (a version of that paragraph, marked to show the change, is appended):

--Figure 1 is a schematic view of a diffraction lens according to a first embodiment of the present invention.--

IN THE CLAIMS

Please amend Claims 1-11 to read as follows (a version of those claims, marked to show the changes, is appended):

1. (Amended) A diffractive optical element made of at least two materials of different dispersions, and including at least two diffraction gratings accumulated one upon another, wherein:

each diffraction grating is formed on a curved surface of a substrate; and a diffraction grating, from among said at least two diffraction gratings, in which a curvature radius of the curved surface and a curvature radius of a grating surface in a portion where a grating pitch is largest, have different signs, is one of said at least two diffraction gratings which has a smallest grating thickness.
2. (Amended) A diffractive optical element according to Claim 1, wherein said diffraction grating having a smallest grating thickness is structured so that an angle which is defined between the grating surface and a grating edge of that diffraction grating is obtuse and is greater than an angle which is defined between the grating surface and a normal to the surface at a position where a plane connecting grating free ends of the smallest-thickness diffraction grating and the grating surface intersect with each other.
3. (Amended) A diffractive optical element according to Claim 1 or 2, wherein the grating edge of the diffraction grating is made parallel to an optical axis.

4. (Amended) A diffractive optical element according to Claim 1 or 2, wherein the curvature of the plane connecting the grating free ends is approximately even, in each diffraction grating of said at least two accumulated diffraction gratings.

5. (Amended) A diffractive optical element according to Claim 1 or 2, wherein at least one of said at least two diffraction gratings is formed at an interface of two different materials having different dispersions.

6. (Amended) A diffractive optical element according to Claim 1 or 2, wherein said at least two accumulated diffraction gratings are bonded with each other in a non-grating region.

7. (Amended) A diffractive optical element according to Claim 1 or 2, wherein said at least two diffraction gratings include at least one grating of a shape in which a direction of the grating thickness is different.

8. (Amended) A diffractive optical element according to Claim 1 or 2, wherein said diffractive optical element is effective to improve a diffraction efficiency of a predetermined order, over a whole visible light region of a used wavelength.

9. (Amended) A diffractive optical element according to Claim 1 or 2, wherein there is a wavelength included in the used wavelength range which wavelength satisfies the following relation:

$$\pm (n_{01}-1) d_1 \pm (n_{03}-1) d_2 \pm (n_{02}-1) d_2 = m\lambda_0$$

where n_{01} is a refractive index of the material of a first diffraction grating with respect to a wavelength λ_0 , n_{02} is a refractive index of the material of a second diffraction grating with respect to the wavelength λ_0 , n_{03} is a refractive index of the material of a third diffraction grating with respect to the wavelength λ_0 , d_1 and d_2 are thicknesses of the first and second diffraction gratings, and m is a diffraction order.

10. (Amended) A diffractive optical element according to Claim 1 or 2, wherein the substrate has a lens function.

11. (Amended) A diffraction optical system including a diffractive optical element as recited in Claim 1 or 2.

REMARKS

Claims 1-11 have been amended, with no change in scope, as to matters of form and to eliminate any improper multiple dependencies.

Applicant's undersigned attorney may be reached in our New York office by telephone at (212) 218-2100. All correspondence should continue to be directed to our below listed address.

Respectfully submitted,

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NY_MAIN 201779 v1

VERSION MARKED TO SHOW CLAIM CHANGES

1. (Amended) A diffractive optical element made of at least two materials of different dispersions, and including at least two diffraction gratings [being] accumulated one upon another, [characterized in that] wherein:

each diffraction grating is formed on a curved surface of a substrate; and [that] a diffraction grating, [of] from among said at least two diffraction gratings, in which a curvature radius of the curved surface and a curvature radius of a grating surface in a portion where a grating pitch is largest, have different signs, is one of said at least two diffraction gratings which has a smallest grating thickness.

2. (Amended) A diffractive optical element according to Claim 1, wherein said diffraction grating having a smallest grating thickness is structured so that an angle which is defined between the grating surface and a grating edge of that diffraction grating is obtuse [more] and is greater than an angle which is defined between the grating surface and a normal to the surface at a position where a plane connecting grating free ends of the smallest-thickness diffraction grating and the grating surface intersect with each other.

3. (Amended) A diffractive optical element according to Claim 1 or 2, wherein the grating edge of the diffraction grating is made [in] parallel to an optical axis.

4. (Amended) A diffractive optical element according to Claim 1 or 2 [or 3], wherein the curvature of the plane connecting the grating free ends is approximately even, in each diffraction grating of said at least two accumulated diffraction gratings.

5. (Amended) A diffractive optical element according to [any one of] Claim[s] 1 or 2 [- 4], wherein at least one of said at least two diffraction gratings is formed at an interface of two different materials having different dispersions.

6. (Amended) A diffractive optical element according to [any one of] Claim[s] 1 or 2 [- 5], wherein said at least two accumulated diffraction gratings are bonded with each other in a non-grating region.

7. (Amended) A diffractive optical element according to [any one of] Claim[s] 1 or 2 [- 6], wherein said at least two diffraction gratings include at least one grating of a shape in which a direction of the grating thickness is different.

8. (Amended) A diffractive optical element according to [any one of] Claim[s] 1 or 2 [- 7], wherein said diffractive optical element is effective to improve a diffraction efficiency of a predetermined order, over a whole visible light region of a used wavelength.

9. (Amended) A diffractive optical element according to [any one of] Claim[s] 1 or 2 [- 8], wherein there is a wavelength included in the used wavelength range which wavelength satisfies the following relation:

$$\pm (n_{01}-1) d_1 \pm (n_{03}-1) d_2 \pm (n_{02}-1) d_2 = m\lambda_0$$

where n_{01} is a refractive index of the material of a first diffraction grating with respect to a wavelength λ_0 , n_{02} is a refractive index of the material of a second diffraction grating with respect to the wavelength λ_0 , n_{03} is a refractive index of the material of a third diffraction grating with respect to the wavelength λ_0 , d_1 and d_2 are thicknesses of the first and second diffraction gratings, and m is a diffraction order.

10. (Amended) A diffractive optical element according to [any one of] Claim[s] 1 or 2 [- 9], wherein the substrate has a lens function.

11. (Amended) A diffraction optical system including a diffractive optical element as recited in [any one of] Claim[s] 1 or 2 [- 10].

A.N. NYA
Atty. Docket No. 684.3256

VERSION MARKED TO SHOW SPECIFICATION CHANGE

Page 10, lines 4-6:

Figure 1 is a schematic view of a diffraction lens according to a first embodiment of the present invention..

NY_MAIN 201779 v 1